JULY 1953

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Battelle Technical Review

IN THIS ISSUE:

Mineral Resources and Our Economy

ANALYTICAL CHEMIST

E. JOHN CENTER

"The analytical accumulation of facts, of course, plays a vital part in technological research. This gives chemical analysis a key role in the modern research organization. No longer content with the traditional chemical services, the contemporary analytical chemist employs a host of physicochemical instruments for the working out of special problems. Such a broad field of activity calls for an analytical team with a wide variety of training and with the skill to devise new methods of analysis as well as to practice those already established."

These beliefs of E. John Center are the fruit of his training and experience in analytical work. His association with Battelle's analytical chemistry division began when he joined the Institute in 1941. Since being named to head that division in 1945, John's primary concern has been to supply Institute technologists with the most effective analytical facilities and to meet their needs quickly.

He recognizes that the accomplishment of these aims requires a flexible, highly coordinated analytical team. The realization of such a division has been aided through work on numerous research projects which has helped to expand and sharpen the know-how of its members.

Under John's leadership, members of his analytical group have worked out a rapid process for the determination of uranium by fluorescence and new techniques for the spectrophotometric and colorimetric determination of certain elements. Among other accomplishments, the division has developed methods of analysis for special alloys, beryllium, and zirconium; equipment for the rapid assay of copper, brasses, and bronzes; and equipment for the purification and separation of elements in the mercury cathode group.

Previous to his association with Battelle, John served as chemist with the Oliver Mining Company. During the same years he was completing work for his chemical engineering degree at the University of Michigan. The year after John's graduation, in 1939, was spent in study under Dr. Hobart H. Willard, an outstanding analytical chemist. It was this association that led John definitely into the field of analytical chemistry.

A family of three girls and a boy makes considerable inroads into John's leisure moments. He does find time, however, to experiment with radio-sound systems and to indulge in a little hunting when the opportunity is offered.

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contents

Analytical Chemist . . . . . Inside front cover

Revolution in Industrial Management . . . 69

An Editorial

Mineral Resources and Our Economy . . . 70

by Richard J. Lund

Rising demands for minerals require us to develop a broad conservation program. Such a program must look to the expansion of consumption rather than the "abstinence and retrenchment", which would hold back progress. Some of the important factors in stretching our mineral resources are technological improvements, the use of alternative materials, imports, and regional planning.

Brighter Future for the Rare Earths . . . 76

by Roland B. Fischer

Expanding supplies and increasing knowledge of the rare earths is giving them a place of growing importance in industry. As improved and more economical methods are developed for isolating them in their pure form, the metals may be expected to find new fields of usefulness.

Notes from Battelle 78

Reports on research activities and developments of interest to science and industry.

Recent Papers and Articles by the Research Staff 80

Papers and articles prepared by members of the Battelle staff that have appeared recently in books and periodicals.

Battelle Technical Review Abstracts 291a

Abstracts of articles from more than 1000 American and foreign technical journals in a wide variety of technological fields.

Studying Electricity in Action . . Inside back cover

Revolution in Industrial Management

ONE OF THE ASPECTS of the Technological Revolution is the changed composition of industrial management. Recent surveys indicate that engineers occupy about 20 per cent of the top executive posts in leading industrial corporations. Engineers now outnumber both lawyers and bankers as board chairmen and presidents of industrial corporations. In the newer industries, based directly upon the results of research, engineers and technologists frequently compose a substantial majority of the board of directors.

This shift in the makeup of management is, of course, an effect of the changed nature of our industrial economy. A highly technical industry requires men with technical training to understand and guide it. Competitive survival demands sound appreciation of technology at the policy-making level.

When any profession gains dominant voice in industrial management, our economic development reflects that dominance. Thus, when the bankers and financiers were dominant, we experienced great capital expansion and the development of our financial structure. The lawyers developed our corporate organization and lines of liaison with government. Sales people have put the accent upon mass marketing and consumption and have been responsible for our advertising and distribution systems. Technical people in management will inevitably think along technical lines and give impetus to technical development. Thus the Technological Revolution—which has put technologists into top management—will be stoked into greater activity by the management it has created.

This can only mean more and more corporate research, greater competition, and better products for the public. It means, too, a different approach to economic and social problems. Technical people tend to think in concrete terms rather than in symbols and are likely to look askance upon proposals too far removed from basic concepts and principles. Thus, overproduction of a commodity will usually be regarded by the technologist as a sign of underdevelopment of its utility, rather than as a need for restriction of production. World problems are more likely to be thought of in terms of materials, energy, and resources, rather than in the usual terms of finance, control, or political ideologies.

Engineers and technologists in management will also help further management relations with the public. The public appreciates the results of technical research and development and has high regard for the engineer's desire to maximize production. The laborer and tradesman can understand technical people, while they may have difficulty in understanding professions less closely allied with laboratories and shops. In turn the engineer and technologist understand the aspirations of workers all along the line and bring to the management team an insight into human nature as well as their guidance on technical decisions.

Clyde Williams

Director, Battelle Memorial Institute

Mineral Resources and Our Economy

by RICHARD J. LUND

Dr. Lund writes from a broad background which includes experience in the fields of geology, mineralogy, and mineral and industrial economics. A one-time editor of the Mining Congress Journal, *he was, during the war years, Director of the Miscellaneous Metals Division of the War Production Board and later Director of Basic Research for the Reynolds Metals Company at Glen Cove, New York. Since 1945 he has directed technical and economic studies at Battelle.*

OUR MODERN CIVILIZATION is dependent on adequate supplies of minerals. Without them, our industrial system could not continue to exist. Yet, in many cases, we are using our minerals faster than we are finding new sources to replace them.

By and large, our minerals are wasting assets. Except for revolving scrap supplies, they are used once and lost to posterity. We can't grow minerals—or at least at rates measurable in generations or even the entire past span of civilization. So we must consider most of our minerals as irreplaceable assets that are being used up at an alarmingly fast rate.

Naturally, we have already used most of the minerals of the best quality that could be found most easily in the largest known quantities and in the most easily accessible locations. The job of finding new deposits becomes increasingly more difficult, but as we will see later, advancing technology fortunately is a compensating factor.

NEED FOR CONSERVATION

In view of our decreasing available mineral resources, their conservation and development has become a necessity. What do we mean by "conservation"? Many will agree with the President's Materials Policy Commission that a sound concept of conservation is "one which equates it with efficient management—efficient use of resources and of man-power and materials: a positive concept compatible with growth and high consumption in place of abstinence and retrenchment." It is not wise to think of conservation in terms of hoarding for the benefit of future generations, because progress then would be hopelessly stymied. Conservation of resources means their judicious development and use, with continuing effort aimed at (1) making a thorough inventory and assessment of present and future supplies, (2) improving technology to raise recoveries and to reduce waste, and (3) substituting, where feasible, replaceable for irreplaceable resources, or more abundant irreplaceable for less abundant irreplaceable resources.

LONG-TERM DEMAND-SUPPLY PICTURE

Under what appears to be reasonable assumptions concerning growth in population, labor force, and productivity, the President's Materials Policy Commission postulates a doubling of gross national product during the next quarter of a century. By further analysis of past trends and plausible assumptions as to the future, major aggregates in the economy are projected, and these, in turn, are broken down into estimated trends for major industrial classes. Finally, from known use patterns of metals and minerals by different industries, plus factors to account for substitution probabilities, projections of future demands for a sizeable number of metals and minerals are made. Briefly, the PMPC forecasts a healthy increase of 90 per cent in the total demand for metals and minerals in 1975 compared with 1950. This average figure has little meaning, however, since it includes variations ranging from 18 per cent for tin up to 1,845 per cent for magnesium. By major groups the increases are as follows:

Iron and ferroalloys	75 per cent
Nonferrous metals	85 per cent
Mineral fuels	97 per cent
Construction materials	35 per cent
Other nonmetallic minerals	133 per cent

For metals other than magnesium the largest increases are for aluminum (358 per cent), cobalt (344 per cent), and titanium and cadmium (324 per cent). For magnesium, 1975 demand estimates range from 100,000 tons to 1,000,000 tons, depending on the extent of technologic progress made.

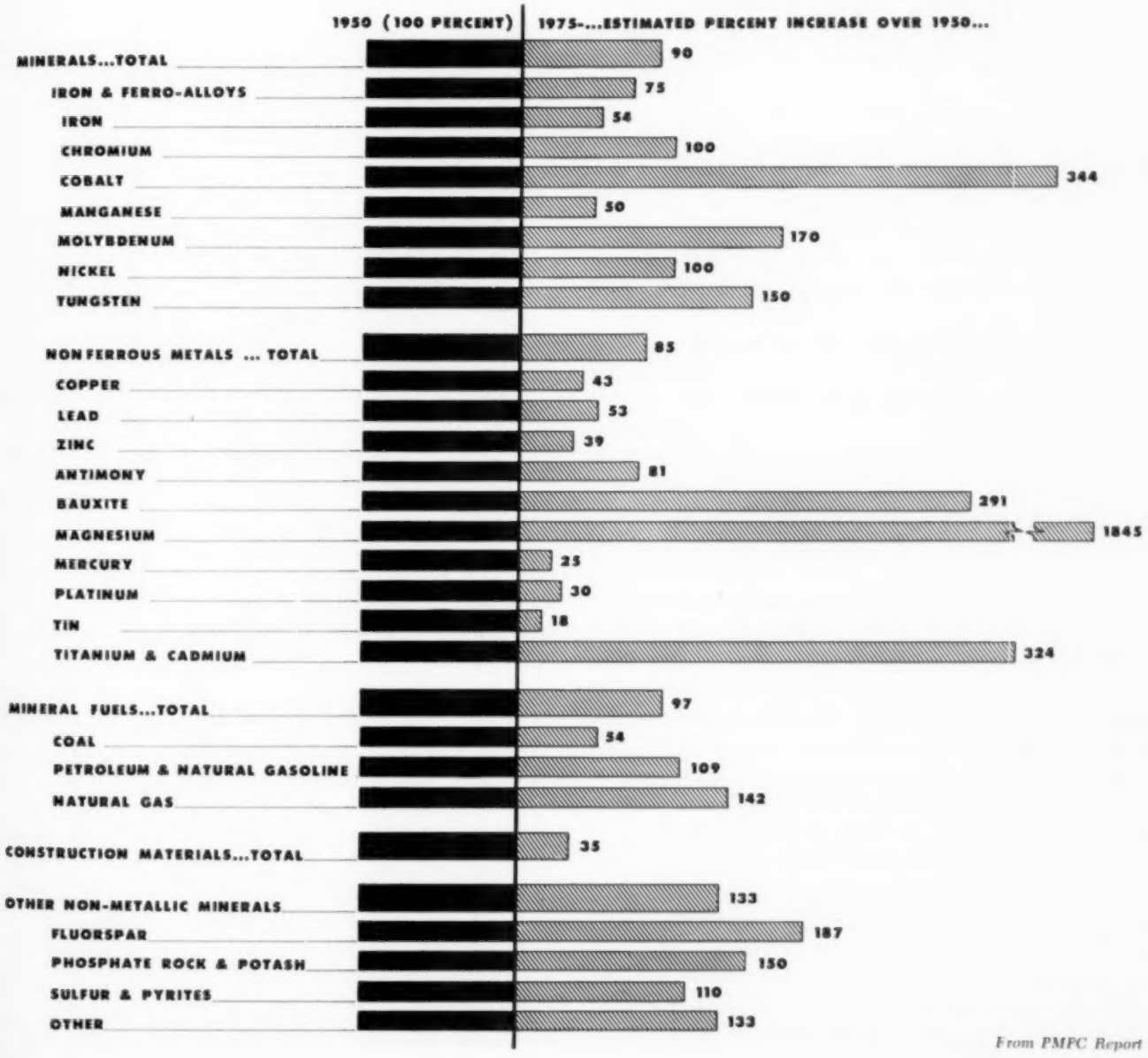
With respect to supplies to meet these estimated

demands, it is difficult to generalize across-the-board on the Commission's findings. However, for many of the common large-tonnage metals and minerals, domestic resources must be greatly strengthened by discovery, and imports must be substantially increased. For a considerable number, known U. S. economic reserves are adequate for well over 25 years: these include magnesium, molybdenum, coal, phosphate, potash, lime, salt, and numerous other nonmetals. For others, including copper, lead, zinc, petroleum, natural gas, and sulfur, known U. S. reserves of commercial grade are inadequate, but geologic discoveries are considered likely though not necessarily adequate. For still others, including iron, aluminum, beryllium, and fluorine, beneficiation progress will make larger lower grade deposits commercially available. Finally, there are little or no known U. S. economic reserves, and little likelihood of significant discoveries, of manganese, chromium, nickel, tin, cobalt, platinum, diamonds, quartz crystal, and asbestos.

Stretching Supplies by Technologic Advances

Contributing to further discoveries in the decades ahead will be technological advances in exploration methods, including geophysics and geochemistry.

ESTIMATED U.S. MINERAL CONSUMPTION BY 1975



From PMPC Report

Other instruments utilizing novel properties of minerals in their location may well be developed. The ultraviolet lamp has assisted much in locating and developing tungsten deposits, and the Geiger counter has been busily clicking over thousands of square miles in locating uranium-bearing rocks and rare earths. We may expect exploration and development of offshore petroleum reserves to get back on the beam now that the question of ownership is finally settled.

Technological advances in upgrading submarginal ores will contribute greatly in certain minerals—notably taconite iron ores, and probably the nickel-cobalt laterites that are present in huge tonnages in nearby areas. Synthesis of minerals holds some promise of solving shortages of sheet mica and quartz crystals. In the much publicized field of liquid fuels, recovery from oil shales probably will precede synthesis from coal, which, according to the recent report by the National Petroleum Council, is too costly to consider seriously while petroleum discoveries are still proceeding so favorably.

In general, recoveries in concentrating, smelting, and refining are already high, and too much improvement cannot be expected. But we will see more attention paid to recovery of minor by-products and co-products from large-scale operations, including many lesser known metals such as germanium, indium, columbium, tantalum, and perhaps gallium and rhenium.

Much conservational progress can be hoped for in improved recoveries in various mining operations, such as coal, and in extraction of petroleum from underground reservoirs. We are still recovering only about 60 per cent of the coal mined underground, and less than 50 per cent of the oil by primary extraction.

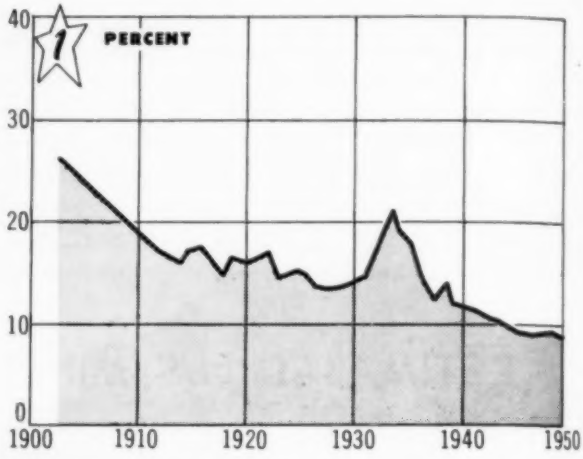
Conservation in Use

Much has been and still can be done in conserving our metals and minerals in their use.

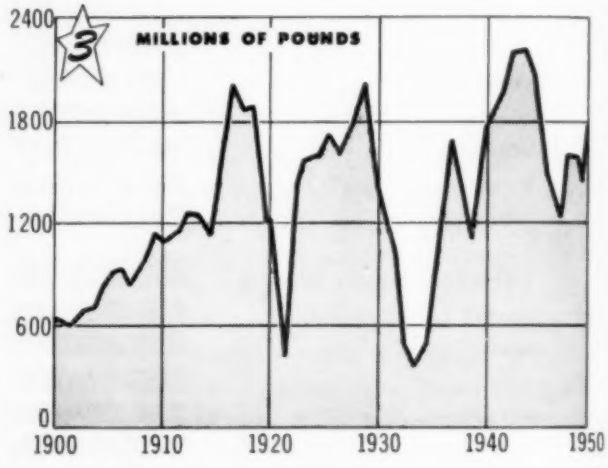
Corrosion is still a great waster of metals, in spite of advances in the technology of protective coatings and corrosion inhibitors. We are all only too familiar with the effects on our automobiles of the practice of dumping salt on streets in the winter to reduce the hazards of ice. It has been estimated that perhaps two per cent of the total 2 billion tons of steel in use is lost as a result of corrosion. This represents not only loss of the metal, but a fabulous amount of labor and materials cost in combating the loss. More and more attention will be given to use of materials that are high in corrosion resistance, such as aluminum and stainless steels, for uses where exposure and maintenance costs are serious. Better coatings will be

TECHNOLOGY HELPS KEEP

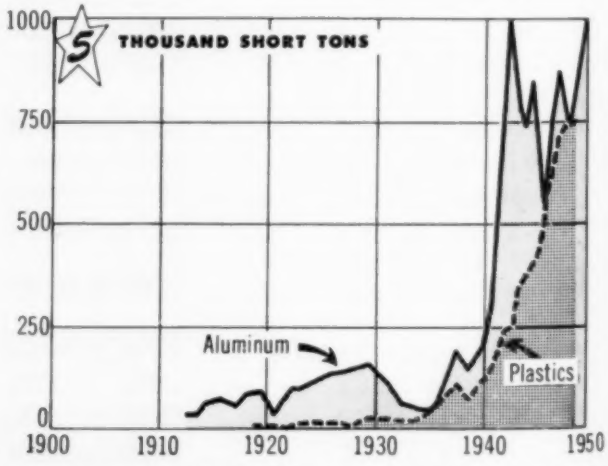
The Copper Story Shows How It Is Done



As high-grade copper deposits were exhausted, industry was forced to use lower grade, higher cost ore . . .

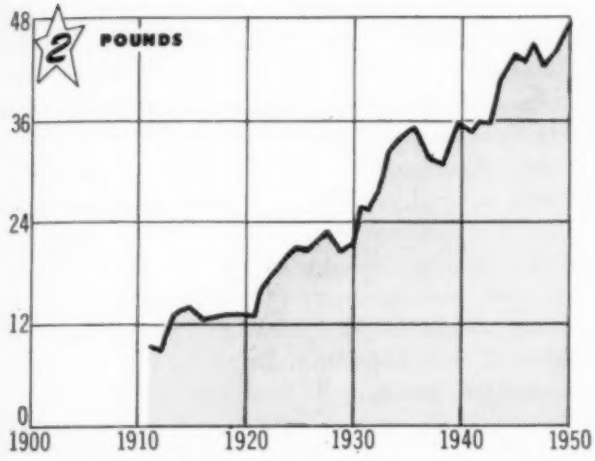


. . . total production was kept high by such means, but as the demand continued to increase . . .

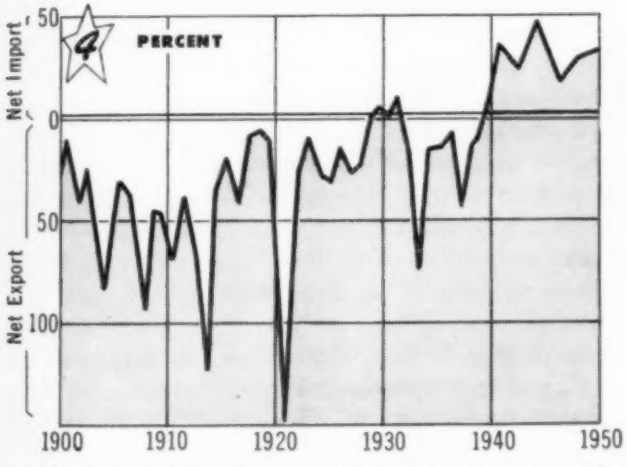


. . . technologists developed aluminum and plastics that could be substituted for copper . . .

U. S. METAL PRICES DOWN

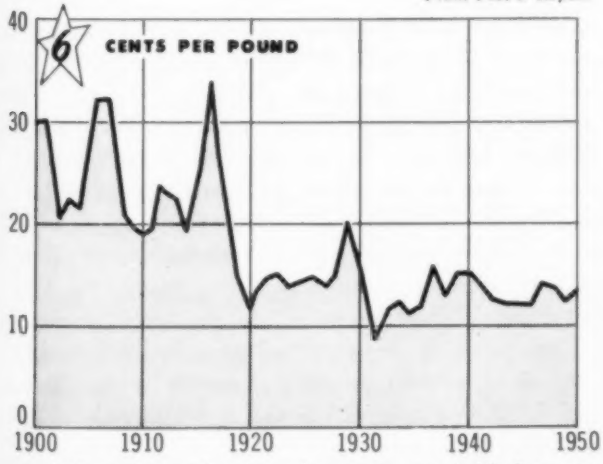


. . . but technological advances kept costs down by raising the output of copper per man-hour . . .



. . . the United States began to import copper to meet its needs. In addition, however, . . .

From PMPC Report



. . . and thus the real price of copper was held down to levels that make its continued use economic.

developed for possible easier application. Cathodic protection by magnesium, already advancing by leaps and bounds, will be practiced even more widely.

Losses of nonrecovered scrap after usage are high. Labor-saving methods of recovering this scrap will be perfected further, as evidenced, for instance, by the techniques recently developed for retrieving steel in junked auto bodies. Efforts have repeatedly been made to recover tin and steel in the lowly tin can after use, and research is still continuing to overcome some of the obstacles that bar commercial success in such ventures. The great reduction in thickness of the tin coating has lowered tin recoveries from some 35 pounds to less than 15 pounds per ton, and made the job doubly hard.

The example just cited, however, of thinner coats of tin on cans by electrolytic deposition illustrates an important step in conservation in use. In 1941, for example, about 45,000 long tons of tin were used in producing about 2.9 million long tons of tin plate, whereas in 1950 only 37,000 long tons of tin were needed to make over 4.2 million long tons of tin plate. The pounds of tin per long ton of tin plate were reduced from 35 to about 20. This figure undoubtedly will be further reduced in the future by substitution of electrolytic for hot-dip practice and by differential coating of the two sides.

An outstanding example of wastage in use is the American automobile, which accounts for such a large part of our petroleum consumption. Here the energy-system efficiency of petroleum usage is only about 5 per cent. Improvements in low engine efficiencies have been made at the expense of lower efficiencies in manufacturing the higher grade fuels needed to operate these engines. And other factors have more than wiped out gains in engine efficiencies—namely, the demand for greater comforts and conveniences in the automobile. Softer tires, radios, heaters, cigarette lighters, automatic devices for moving tops, windows, and seats, power steering, and finally even air conditioning are reducing the possibility of conserving on fuel. It is hard to say when the motoring U. S. public will be interested sufficiently in better mileage to sacrifice weight, speed, and some of the conveniences—it will probably take a bigger boost in gasoline prices than appears probable in the next decade or two.

Substitution to Play Prominent Role

A potent factor in meeting our total mineral needs will be the substitution of one mineral for another, or of synthetics such as plastics made from common mineral raw materials or agricultural materials for scarcer minerals. Aluminum has only begun to make itself felt in this movement, where it has already taken

over substantial copper markets in electrical and building uses, and of lead and zinc in certain fields. Manganese may well crowd nickel out of some of the large alloying uses in stainless steels. Once costs are reduced, titanium may take over many uses of stainless steel. Zirconium might well take the place of much of the tantalum in equipment requiring high resistance to certain forms of corrosion. And finally, we may expect new forms of tile, brick, glass, and light-weight aggregate to play a more important role in building construction and other applications.

Price the Great Governor

We do not have to be reminded that price of basic raw materials is the great governor of demand and supply in the free economy that has made us great. But price is also the crux in tipping conservational practices one way or the other. High prices stimulate search for new ore deposits, development of lower grade resources, secondary recoveries from the ground, recycling and recovery during and after use, and substitution. Low prices encourage the opposite—stoppage in exploration, production only from higher grade deposits, and wastage and nonrecovery in use. In this latter connection, we need only recall, as a vivid example, the sad wastage of 25-cent-per-barrel petroleum in the early 1930's, when uncontrolled flush production flooded shrinking markets. Fortunately, this will never happen again. State controls are operating to prevent such a situation in all important producing areas.

Since price is such a vital factor in encouraging or discouraging conservational practices, any program aimed at judicious development and use of our mineral resources is made all the more complex.

Greater Reliance on Foreign Supplies

Increases in demand, of the size forecast by PMPC for many minerals, can be met only in part by discoveries and improved technology applied to domestic resources. Heavy reliance must be placed on foreign supplies to take up the slack. And in doing this, care must be taken that domestic mineral industries not be crippled. Security considerations and a square deal to domestic industries dictate that such a policy be followed. Perhaps a sliding-scale import tax such as now advocated by lead and zinc producers is a partial answer.

It might not be too easy to insure that we get the supplies we need from abroad. Nationalistic programs springing from spreading socialism are eliminating large areas from possible investment and development by United States firms. Instead of an "open-door" policy for foreign mineral development, the whole trend is toward shutting the door tighter. And boosts in mineral needs by the growing economics of foreign countries will require larger pieces of the pie.

Fortunately these factors are not stopping us in some areas. The huge investments being made by U. S. firms for iron and titanium in Canada, iron in Venezuela and Liberia, manganese in Brazil, bauxite in Jamaica, and copper, lead, and zinc in South West Africa, are only a few notable examples of successful foreign mineral ventures by United States companies.

But because we must place heavier reliance on foreign supplies does *not* by any means brand us as a "have-not" nation! In the recent words of Howard Young, former Deputy Administrator of the Defense Materials Planning Administration, we are rather a "need-more" nation.

Vital Role of Local and Regional Studies

Whether it is a matter of cataloguing for easy reference the mineral resources along a railroad's extended system, or making an inventory of such resources in a utility's electric system, local and regional studies of minerals are receiving growing attention these days. Many data are available concerning such local resources, but they are scattered through thousands of publications and unpublished files of Federal organizations, state geology surveys, and individual companies. This work performs an invaluable service to industries by helping them locate where the situation as to various plant-site factors, including raw-materials availability, is most favorable. Research teams at Battelle have made numerous studies of this sort, ranging from a regional mineral-resource study in Southeastern Ohio to one on fuels for the State of Washington.

It is important to know not only the mineral resources of an area but also the consumption of raw materials by established industries within the area. In many cases little is known—in any detail—about consumption of minerals by local areas or regions. This fact struck home forcefully a couple of years ago when the author was preparing a paper for the First Ohio Mineral Industry Conference, which attempted to show some details on the importance of Ohio industries as consumers of minerals. It was very difficult to find quantitative information, most of which had to be developed by applying factors to data on output of finished products. The Federal Reserve Bank in St. Louis is reported as pioneering in such an analysis of industrial input and output of raw materials and finished products for the district covered by its activities.

The Houston Chamber of Commerce recently made

an impressive consumption study of its area. By canvassing industries in the area on their raw-material requirements, the Chamber was able to show a real opportunity for other industries to come into the area to supply some of these needs. Justification for new steel capacity was a notable conclusion.

Such studies not only help in locating new industries; they may result in improving the economic health of local established industries, and hence, strengthen the economy of the entire area.

A Philosophy for Local Improvements

The regional approach to economic improvement is relatively new. If it is to be most effective, those concerned with local planning must be awake to their responsibilities in the over-all picture. The following discussion suggests a constructive philosophy that can be applied to the exploitation of all local resources.

It is possible that many of us tend to lose sight of the fact that inter-industry and inter-regional dependence is intense and that we are not really competing at the expense of others but rather for mutual benefit. Efforts toward pure self-sufficiency are not progressive, for in such direction lies ultimate stagnation. So long as one or more areas are underdeveloped, others cannot enjoy the full growth that would be possible with improvements in the economic health of all communities. We hear of this philosophy in such international efforts as "Point Four" and in government-espoused plans such as TVA, REA, and other similar programs.

The difficulty in maintaining flourishing local economies seems to be due to several factors. Certain areas have been in trouble because of complacency in "established" superiority of business acumen, "inexhaustible" resources and markets, and competitive advantages, or because of indifference to the plight of other areas. New England, the anthracite regions of Pennsylvania, and specific industries such as the soft coal, cotton, wool and dairy industry have lost ground on a temporary or nearly permanent basis for reasons in this category.

Other areas can fall or are falling into troublous times because of inept or inadequate planning based on insufficient knowledge of real strengths and weaknesses in raw materials, labor, markets and other vital factors. A corollary of this is the tendency to raid other regions for industries that will leave the older location. Each area may thus be weakened—one through the loss of industry, the other through acquisition of an industry that may not thrive.

If government subsidy and "interference" are to be avoided, thereby promoting the free enterprise system and the economic health of the nation, then the "complacency" of the old areas and industries and the haphazard practices of "growth" areas will have to be eliminated.

We should therefore examine the broad picture through successive steps:

1. Area soul-searching to see what we are really thinking and doing. Is the motive behind our industrial development a stop-gap development, an emotional activity, a "keeping-up-with Jonestown", an isolationist principle, a speculative fever, or a sound, economic program that takes cognizance of what part the area can effectively play in the broad scheme of national development?

2. Consider abandoning efforts that do not contribute to regional or national improvement or that actually hinder it. If technological advances have begun to leave an area struggling for survival it would be well to recognize this condition as early and honestly as possible rather than to seek subsidies, laws, or other artificial crutches for a prospective corpse.

3. Be concerned with improving and adding to the things we do or could do better than those in other areas. This phase will require very careful analysis of the interdependence of several industries. Supplementing existing plants with others to supply unfinished materials or consume semifinished or finished manufactures is a vital step in regional improvement. Especially in a drastic change of activity, careful analysis and a long-range plan for an integrated industrial community are essential.

The readjustment of local economies can have a far-reaching effect in improving our national economy. Thus, the judicious location of industries plays an important part in the conservation and most effective development of our mineral resources. By making possible the economic exploitation of local resources, local development will add to our available national wealth.

Brighter Future for the Rare Earths

by ROLAND B. FISCHER

The author has conducted and directed a wide variety of investigations in the fields of physical metallurgy including the use of rare-earths, alloy development, very high-temperature metallurgy, and the solution of unusual metallic-materials problems. Following service with the Army Corps of Engineers, Fischer served as a metallurgist in the research laboratories of the American Smelting and Refining Company. He has been associated with Battelle since 1946. His previous publications include articles on the metallurgy of molybdenum and tungsten.

THE SO-CALLED "rare earths" are a number of metals which are grouped together in the Periodic Table. Seldom heard of by most people, the metals were, for a long time, difficult to isolate in their pure state. This discouraged scientists, and little research was done on the rare earths. However, within the last few years, knowledge about them has increased and the metals are gaining a position of increasing importance in industry and technology.

The fourteen metals of the group have the following tongue-twisting names: cerium, promethium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutecium. Three others, lanthanum, yttrium, and scandium, are frequently attached to the rare-earth group because of their occurrence in some rare-earth minerals such as monazite rather than because of their close relationship in the Periodic Table.

FACTORS ENCOURAGING EXPANDED USE

Several factors are encouraging the development and expanded use of the rare-earth metals. First, recent discoveries of large domestic resources of raw materials assures a supply adequate to support great expansion in their use for years to come. The rare earths will not be produced in tonnage quantities usual for such common metals as steel, copper, and aluminum. They will, however, find increasing applications because of the specific benefits derived from their use. Second, improved technological practice is providing scientists with greater quantities of the individual rare earths, thus making possible more complete studies of their industrial applications. Third, new markets for the use of the rare earths may develop in steelmaking, aviation, electronics, and atomic energy fields as a result of expanding studies.

Metallurgists have found that the addition of small amounts of the rare earths can improve the qualities of some primary metals. When added to magnesium, for example, the rare-earth metals markedly increase the strength and resistance to slow deformation under load (creep resistance) at high temperatures. Rare-earth additions to certain steels have been observed to improve their quality and to make them easier to work into desired shapes.

Heretofore, it has been extremely difficult to isolate the individual rare earths because they occur together and are very much alike chemically. As many as 40,000 operations have been required to get some of the rare earths really pure. Present commercial usage, consequently, has been largely confined to oxides and misch metal, a mixed form of the rare-earth metals usually consisting of 50 per cent cerium, 30 per cent lanthanum, and a 20 per cent combination of the other rare-earth metals with a trace of iron.

In addition to the metallurgical applications, some uses for the rare earths are as misch metal, to make "sparking" flints for cigarette lighters and toys, and as oxide and fluoride compounds in the cores of arcing carbons for moving-picture projectors and searchlights, where they produce light of intense brilliance. Other uses are as oxide or carbonate compounds in the glass industry for coloring, polishing, and special optical effects, and in the electronics industry for making capacitors. For these and more highly specialized uses, the total consumption of monazite sand, from which misch metal and the rare-earth compounds have been derived in the past, amounted to about 3,000 to 4,000 tons in the United States in 1951.

SOURCES OF THE RARE-EARTHS

Monazite sand has customarily been imported from India and Brazil. India, in 1949, and Brazil, in 1951, imposed embargoes on the exports of the mineral. This was done apparently to set up rare-earth processing operations for sale of more profitable finished

products, and to curtail recovery of thorium for atomic energy uses by other countries. The price of monazite soared from $60 to $300 per ton in the United States. Old domestic sources that previously had been unprofitable to work were then reopened. An intensive search for rare-earth deposits also followed in an attempt to make our country independent in supply of the metals.

The recent search has brought forth startling discoveries of large deposits of rare earths in several western states, including California, New Mexico, and Idaho. The most promising discovery is contained in a huge "barite-carbonate rock" deposit, rich in bastnasite, found in southern California. The mineral bastnasite is a compound of cerium, lanthanum, and other rare-earth metals. Recent reports, based on drilling, show that this deposit may contain a very high potential in tonnage of the rare-earth metals.

Interest of Atomic Energy Commission

Wider industrial usage of the rare earths has been brought closer also by the work of the Atomic Energy Commission in developing a more rapid, efficient method of separating the individual metals. The AEC has a stake in the rare earths because of possible applications. Furthermore, the metal thorium, usually found associated with the rare earths, though not in bastnasite, is under study as a possible raw material for atomic energy generators.

The AEC's improved method for separating the individual rare-earth metals is based on "ion exchange". It is expected that the ion-exchange method will be used most extensively to isolate the more closely bound rare earths, such as neodymium and praseodymium. The more common rare earths, cerium and lanthanum, will probably still be separated by the conventional method known as fractional crystallization. A number of commercial firms are reported to be producing the rare earths by both methods.

There has not been much demand for the individual rare earths because so little is known about their individual properties, and only small quantities of isolated metals have been available for research. The tendency in the future, however, will be to separate the individual metals into pure form. A frequent result of purification is to give an entirely new field of usefulness not realized from the impure metal of the past. Speedier progress toward new uses is now possible, thanks to more efficient methods for recovering the pure rare earths and to a great improvement in the domestic supply of the raw materials.

"We happy few who are professional scientists are a young brood. We must remember not only how old man is but how young is the formal organized knowledge of the natural world. Above all, we must remind ourselves that in the long run scientific research can prosper only in a favorable climate of public opinion. The effective and intelligible popularization or diffusion of the results of science thus become basic in our democracy if the opportunity for the generous continued support of science is to continue.

" . . . The Society for the Propagation of the Gospel helped the spread of religion on these shores in colonial times. Today we still need a society for the propagation of the understanding of the true place of science in our society. The great human advantages that can come to the world in which we live through the proper support of science must be told and told again in clear and popular language, and we must do the telling."

—Dr. Leonard Carmichael in his inaugural address as Secretary of the Smithsonian Institution.

Notes From Battelle

APPLIED TECHNOLOGY AND PROGRESS

In the past 25 years, American production has more than doubled. Yet, in spite of the increase in the size of the labor force, the total number of man-hours worked in 1952 was about the same as in 1928, because of shorter working hours. At the same time, American family income—at constant dollar values—has doubled in size. Gerard Piel, publisher of *Scientific American*, presented these figures recently before the Commonwealth Club of California. They are impressive. But we found that his explanation of how this progress came about was even more interesting.

Piel pointed out that in 1928 there were about 200,000 engineers at work. Today, we have 400,000 engineers engaged in technical activities. He continued: "It is that fast growing corps of engineers, and even faster growing corps of industrial research scientists—that has multiplied the productivity of the American labor force." American industry has rebuilt its plant almost 100 per cent in the past 25 years, and these people have been designing the latest findings of research into plants, processess, and products. "Technology in every major industry is now in permanent flux. Industrial invention . . . is an established function, like sales and production, of modern industrial management. A new Technical Management element has taken its place beside business management in directing the affairs of industry. The task of the industrial scientist is to systematically mine the accumulated capital of basic scientific knowledge for its practical application to technology. They are thus bringing applied science into closest liaison with current progress in the pure sciences."

LOW-TEMPERATURE BEHAVIOR OF STEEL

The problem of the low-temperature behavior of steel is as old as Man's use of the metal. However, only in recent years has it seemed necessary to do something about the problem. Interest has been stimulated by failures of welded ships, bridges, and pipe lines at winter temperatures as well as by the development of low-temperature industrial processes and the Arctic maneuvers of the Armed Forces. Research, therefore, has been directed to brittle-sensitive materials and to the influence of temperature on their embrittlement.

Many factors contribute to the low-temperature behavior of steels. A consideration of the metallurgical factors was presented before the Symposium on Metallic Materials at Low Temperatures of the ASTM-ASME Joint Committee on the Effect of Temperature on the Properties of Metals by Clarence H. Lorig, Assistant Director of Battelle.

In his paper, "Metallurgical Aspects of Low-Temperature Behavior in Ferrous Materials," Lorig pointed out that the behavior of the brittle-sensitive steels at low temperatures is closely related to composition, alloy content, microstructure, and heat treatment. He stated that purity of the metal is probably not the answer to embrittlement. Rather, a more profitable approach is in the direction of controlling the composition, deoxidation, microstructure, and grain size of the metal and of improving techniques of manufacture and fabrication.

NEW FILM-TYPE RESISTORS

Electrical resistance units for use in planes must have the ability to stand up under extreme operating conditions. They must operate in tropical and arctic temperatures. Such units also must resist attack by water vapor and have good oxidation resistance at temperatures ranging from –65 C to 200 C. Other necessary properties are low voltage dependency, resistance to change resulting from temporary electrical overloads, and general ruggedness in the face of sudden temperature changes and vibration.

An investigation on film resistors has been carried on at Battelle for Wright-Patterson Air Force Base. It was recently reported in a paper, "The Nitrides of Chromium and Chromium-Titanium Alloys — New Film-Type-Resistance Elements," by E. R. Olsen, E. H. Layer, and A. E. Middleton.

As an outgrowth of earlier investigations, the authors and their colleagues turned to alloy systems of nitrides, silicides, and borides as promising film materials for study. Test units were prepared by vapor depositing the materials on ceramic rods. After careful evaluation, chromium and chromium-titanium nitrides were selected for further study.

Both types of films exhibited fairly good resistance

to oxidation. Changes in the resistance of the nitrided chromium-titanium films varied from 0.01 per cent at 100 C to 0.8 per cent at 200 C, and 6.7 per cent at 250 C for 200 hours of test after an initial 150-hour pretreatment at 200 C.

Moisture-resistance tests at 95 per cent relative humidity at 75 C on both types of films, without protection, showed less than 3 per cent change in 500 hours. Temperature cycling from −65 C to 200 C for five cycles produced changes in resistance of less than one per cent for both types of films.

The careful control of evaporation conditions is absolutely necessary. Also, because of the thinness of the deposited films, care must be taken to avoid the use of ceramic bases with defects which can easily cause faulty performance.

TREATING ZIRCONIUM

Zirconium and its alloys cannot be soldered, brazed, or hot-dip coated by conventional methods used in treating other metals. Conventional fluxes either do not remove the zirconium surface film or do not provide a surface easily wet by the brazing or hot-dipping alloy. An investigation led by Battelle staff members W. C. Schickner, John G. Beach, and C. L. Faust showed that after the application of a zinc coating, it is possible to treat zirconium. The coating is applied by dipping zirconium into molten zinc chloride at 419 to 500 C for about one minute. The coated zirconium is then cooled, washed with water, and dried. The metal can then be tinned, soft soldered, or silver soldered by conventional methods.

STUDY OF TIN OXIDE BODIES

Tin oxide has thermal-shock properties that compare favorably with those of other ceramic materials. However, little or no published information is available on the thermal conductivity of low-porosity tin oxide or the physical properties of ceramics made of the material. A paper on "Properties of a Tin Oxide-Base Ceramic Body", prepared by John Quirk and C. G. Harmon for the recent Annual Meeting of the American Ceramic Society, presented data on some of the properties of the oxide body.

In their investigations, the authors measured some of the thermal and mechanical properties of sintered tin oxide-matrix compacts composed of 99 per cent tin oxide and one per cent zinc oxide. The sintered compacts were found to be similar in strength, at room temperature, to technical porcelains of the mullite or sillimanite type. They were superior in resistance to thermal shock and strength at 1000 F. On the basis of the results of the investigation, it appears that the tin oxide body might be expected to give good service under conditions of severe thermal shock and in an oxidizing atmosphere at temperatures up to 1500 F.

ABRASION IN WIRE ROPES

Steel that is subjected to high-pressure abrasion usually has a short service life. Railroad rails and wheels and wire ropes are particularly subject to abrasion as a result of the kind of use they receive. In this connection, wire rope used in gear for arresting planes landing on aircraft carriers suffers rapid deterioration in use. As a result, the Navy's Bureau of Aeronautics asked Battelle to explore the causes of high-pressure abrasion failures.

Investigations directed by J. K. Thompson disclosed that one of the most damaging effects of abrasion is the resulting embrittlement of the surface of the steel. Brittleness is caused by the transformation of a thin surface layer of the metal to martensite, a very hard form of steel. The change is brought about by heating and then rapid cooling of the surface. Pressure and sliding speed are so great that considerable heat is generated by friction. Since most of the metal remains cool, heated portions of the surface undergo a rapid quench.

Solution of the problem appears to lie partly in the selection of abrasion-resistant steel. Ferritic alloy steels such as SAE 52100, for example, tend to resist the formation of martensite. The most effective material for use in plane arresting gear as found in the research, however, is cold-drawn improved plow steel. Another approach to resisting abrasion involves coating wire ropes with lead, although such coating is not effective when used with hard wire.

Since the presence of carbon is an important factor in the formation of martensite in iron, the amount of the element in the iron must be considered when selecting a steel for resisting abrasion. Although some more costly nonferrous alloys, such as the cobalt-base alloys, are quite abrasion resistant even under severe conditions, it appears that these qualities may be equaled by careful selection and treatment of steels.

RECENT PAPERS AND ARTICLES BY THE RESEARCH STAFF*

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Axial-Load Fatigue Properties of 24S-T and 75S-T Aluminum Alloy as Determined in Several Laboratories. H. J. Grover, W. S. Hyler, Paul Kuhn, Charles B. Landers, and F. M. Howell. National Advisory Committee for Aeronautics, *Technical Note 2928*, May, 1953.

The Stress-Step Method of Obtaining Short-Term Life Ratings on Electronic Components. A. P. Jerencsik and W. T. Sackett, Jr. National Electronics Conference *Proceedings*, 1952.

Gas-Turbine Fuel From a Pressurized Gas Producer. Harlan W. Nelson, Herbert H. Kouns, and Bruce O. Buckland. A paper in the book, *Gasification and Liquefaction of Coal*, American Institute of Mining and Metallurgical Engineers, 1953.

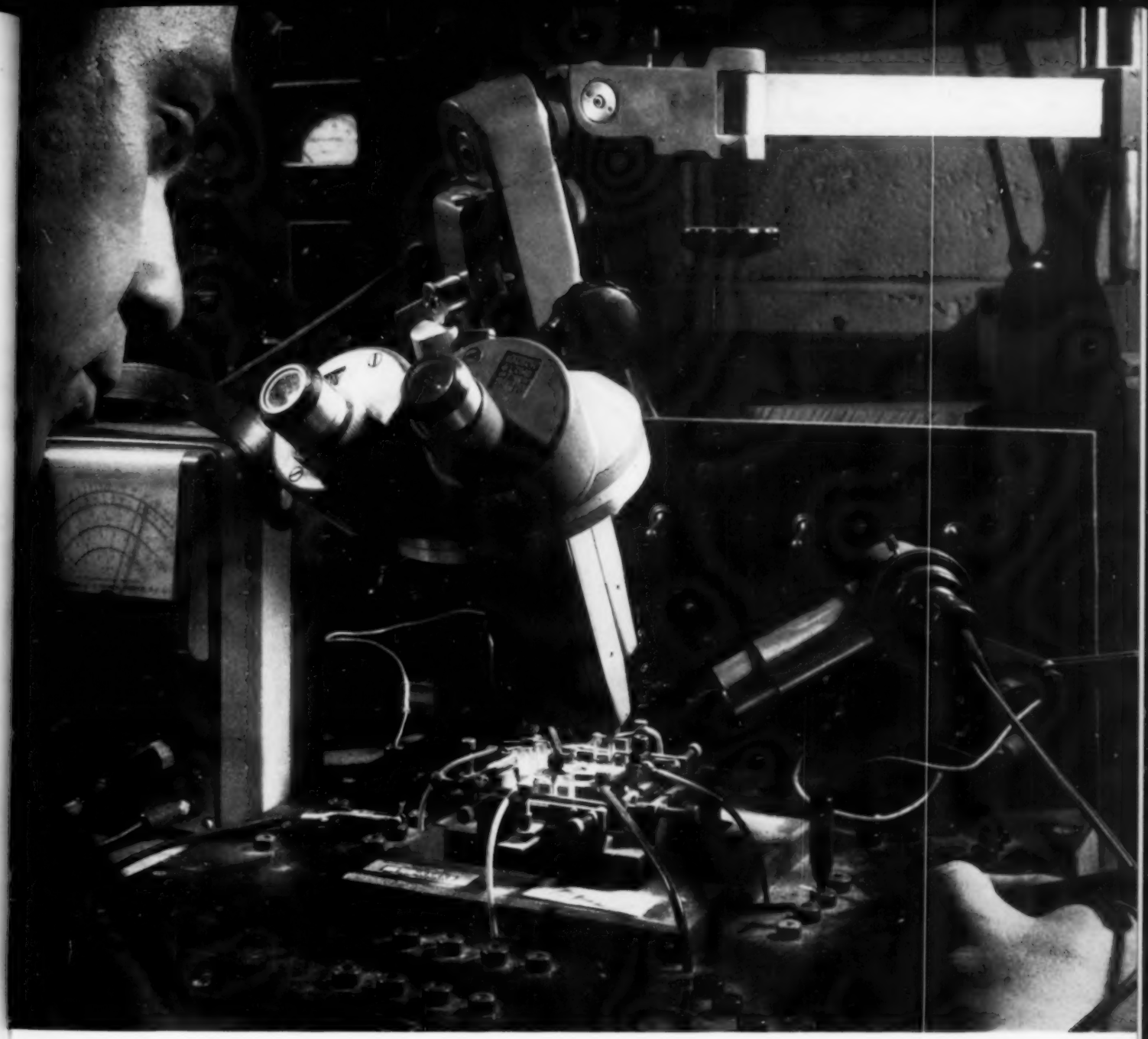
A Study of Burner Oscillations of the Organ-Pipe Type. A. A. Putnam and W. R. Dennis. American Society of Mechanical Engineers *Transactions*, January, 1953.

How to Braze and Solder Zirconium. W. G. Schickner, John O. Beach, and C. L. Faust. *Steel*, May 4, 1953.

The Behavior of Gases in Solid Iron and Steel. C. E. Sims. A paper in the book, *Gases in Metals*, American Society for Metals, 1953.

Properties of Beryllium. Murray C. Udy, Homer L. Shaw, and Francis W. Boulger. *Nucleonics*, May, 1953.

*In most cases, reprints will be available from the Battelle Publications Office on request.



STUDYING ELECTRICITY IN ACTION

The "micro-manipulator" is used in the delicate checking that is necessary in the study of transistors and semiconductors. The microscope, in connection with electronic equipment, makes it possible to note electrical interaction between closely spaced points on semiconductor materials and the interaction of light and the electrical properties of the materials. With the device, the technologist can actually measure the flow of charge between two points and the time delay in the transfer of the charge to one-millionth of a second.

BATTELLE INSTITUTE was founded by the will of Gordon Battelle as a memorial to the Battelle family. The Battelles were among the first settlers of Ohio and were prominent in the development of the state's iron and steel industry.

Gordon Battelle, last of the family line, was impressed with the benefits to be derived from industrial research and left his estate for the building and endowment of an Institute "for the purpose of education . . . the encouragement of research . . . and the making of discoveries and inventions for industry." The Institute began operations in 1929.

As established, Battelle provides, on a not-for-profit basis, the physical plant, equipment, and personnel for conducting research. The great bulk of it is applied research conducted for industry and government.

In keeping with its educational function, the Institute also conducts fundamental or basic research. The results of much of this research are published for the general encouragement of science and industry, and to benefit the public welfare.

Fields of research at Battelle include agriculture and practically all the industrial and engineering sciences.

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